FUTURE OF FRONTRUNNER – FIRST STEPS - PHASE 2

BENEFIT-COST ANALYSIS SUPPLEMENTARY DOCUMENTATION

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FY2020 BUILD DISCRETIONARY GRANT PROGRAM

PREPARED FOR: UTA
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wsp

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the Future of FrontRunner – First Steps – Phase 2 for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the BUILD 2020 program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The period of analysis corresponds to 30 years and includes 4 years of construction and 26 years of benefits after operations begin in 2024.

The project primarily consists of double tracking 2.5 miles of the FrontRunner commuter rail route between South Jordan and Draper stations in Salt Lake County, UT. The single tracking between the two stations is currently a critical point for FrontRunner operations. Adding double track will improve the reliability of FrontRunner service.

Another component of the project consists of wayfinding improvements at Vineyard Station, Draper Station, and South Jordan Station. As part of UTA's continued focus on customer experience, new wayfinding guidelines have been identified. The project will involve the first installation of the new signage.

COSTS

The capital cost for this Project is expected to be $37.9 million in undiscounted 2018 dollars through 2023. At a 7 percent real discount rate, these costs are $30.2 million. Operations and maintenance costs are projected to be similar in the Build and No Build scenarios, so have not been included.

BENEFITS

In 2018 dollars, the Project is expected to generate $33.7 million in discounted benefits using a 7 percent discount rate. Most of these benefits result from travel time savings due to reliability improvements as a result of the project. This leads to an overall project Net Present Value of $3.5 million and a Benefit Cost Ratio (BCR) of 1.12. The overall project benefit matrix can be seen in Table ES-1.

Table ES-1: Project Impacts and Benefits Summary, Monetary Values in Millions of 2018 Dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Page Reference in BCA
Single track segment causes delays	Double track will reduce delays	Improved travel time reliability	FrontRunner Users	Improved Travel Times	$24.9M	p. 9

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Page Reference in BCA
Delays from single track segment reduce ridership	Improved on-time performance (OTP) increases ridership	Reduced vehicle miles traveled (VMT) from additional FrontRunner passengers	FrontRunner passengers	Reduced vehicle operating expense	$4.1M	p. 12
Delays from single track segment reduce ridership	Improved on-time performance (OTP) increases ridership	Reduced VMT from additional FrontRunner passengers	Society at large	Reduced risk of highway accidents	$2.3M	p. 13
Delays from single track segment reduce ridership	Improved on-time performance (OTP) increases ridership	Reduced VMT from additional FrontRunner passengers	Society at large	Reduced emissions from highway travel	$0.02M	p. 14
Delays from single track segment reduce ridership	Improved on-time performance (OTP) increases ridership	Reduced VMT from additional FrontRunner passengers	Society at large	Reduced pavement damage	$0.02M	p. 14
Delays from single track segment cause locomotives to idle	Fewer delays	Less time idling	UTA	Reduced fuel cost	$0.05M	p. 13

Source: WSP, 2020.

The overall Project impacts can be seen in Table ES-2, which shows the magnitude of change and direction of the various impact categories.

Table ES-2: Project Impacts for Project, Cumulative 2024-49

Category	Unit	Quantity	Direction
Passenger Hours of Delay	PHT	2.0M	▼
Vehicle-Miles Traveled	VMT	30.5M	▼
Fuel Consumed	gallons	912,963	▼
Fatalities	#	0.2	▼
Injury Accidents	#	17	▼
Property Damage Only (PDO)	#	41	▼
CO_2 Emissions	tons	5,842	▼
NO_X Emissions	tons	0.72	▼
PM^{10}	tons	0.06	▼
SO_X	tons	0.04	▼
VOC	tons	0.11	▼

Source: WSP, 2020

In addition to the monetized benefits presented in Table ES-2, the Project would create a number of benefits that are difficult to quantify but are substantial:

QUALITY OF LIFE

— The wayfinding improvements as part of the project will help customer experience. Unfortunately, no method is currently available to quantify these improvements.

ECONOMIC COMPETITIVENESS

— The project by itself will not enable UTA to increase service or change the FrontRunner schedule. Rather, the project is a component of a series of capacity improvements that would enable the FrontRunner to increase service. A study completed for UTA anticipates double tracking 46 miles (34 miles under an electrification scenario) between Ogden and Provo so that the FrontRunner could eventually double service frequency.[1] The current "First Steps" project brings the FrontRunner 2.5 miles closer to that goal. Future schedule enhancements the project helps to enable have not been quantified.

SAFETY

— Because the project will help to enhance capacity in the long-term and reduce vehicle usage, it will reduce the risk of highway accidents, injuries, and fatalities.

STATE OF GOOD REPAIR

— Because the project will help to enhance capacity in the long-term and reduce usage of roadways on the Wasatch Front, particularly during rush hour when roadway capacity is needed the most

[1] Prepared for UTA, *Future of FrontRunner Final Report*, September 2018, https://www.rideuta.com/-/media/Files/About-UTA/Reports/2019/C5016_UTA_Operations_Simulation_Tech_MemoV2_20190320.ashx?la=en.

ENVIRONMENTAL SUSTAINABILITY

Because the project will help to enhance capacity in the long-term and reduce vehicle usage, it will reduce vehicle emissions.

While these benefits are not easily quantifiable, they do provide real advantages and improvements that will be experienced by individuals and businesses in the region.

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A benefit-cost analysis (BCA) was conducted for the Future of FrontRunner – First Steps – Phase 2 for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the BUILD 2020 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be negatively impacted as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs.[2] This methodology includes the following analytical assumptions:

- Assessing benefits with respect to long-term outcomes defined by the U.S. DOT;
- Defining existing and future conditions under a No Build base case as well as under the Build;
- Estimating benefits and costs during project construction and operation, including 20 – 30 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2018 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values;
- Discounting future benefits and costs with real discount rates of 7 percent consistent with U.S. DOT guidance;

[2] https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf.

2 PROJECT OVERVIEW

2.1 DESCRIPTION

UTA's FrontRunner commuter rail is the transit backbone for the Wasatch Front, the metro region in the north-central part of Utah. The area includes some of the fastest growing areas of the United States. For example, according to the U.S. Census Provo-Orem Metropolitan Area population increased by 23 percent between 2010 and 2019, making it the ninth fastest growing of 384 U.S. metropolitan areas. The Salt Lake City and Ogden metropolitan areas are each among the 50 fastest growing metropolitan areas.

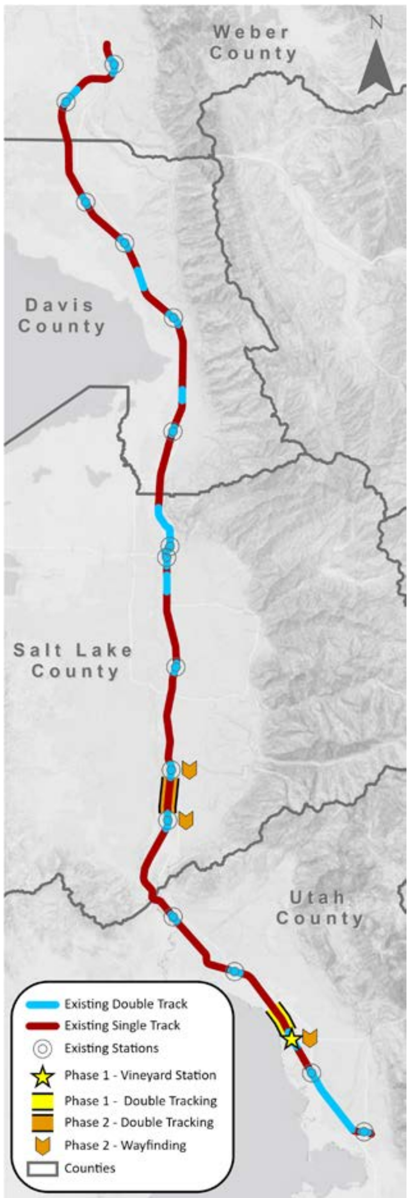


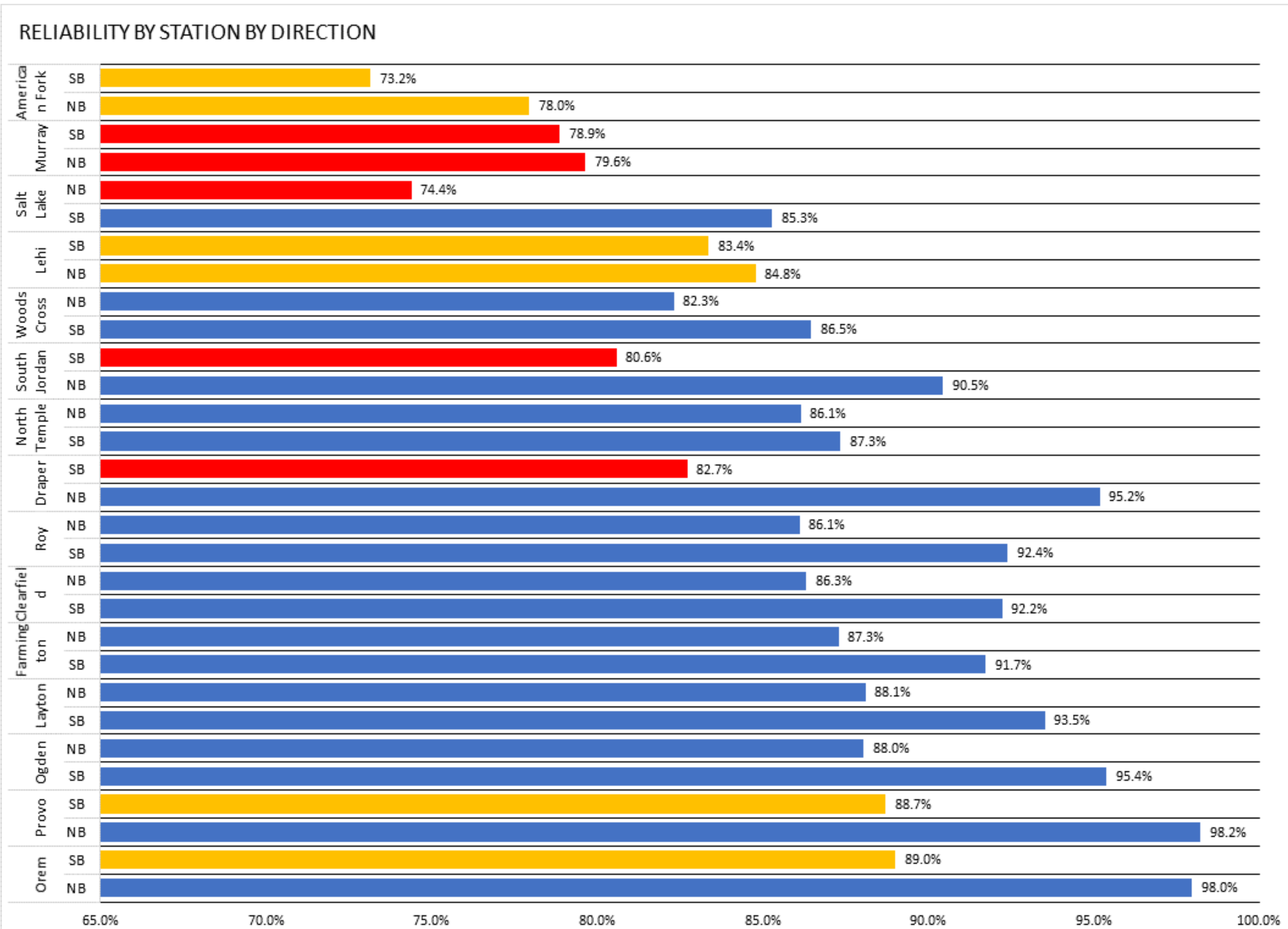
Figure 1: Future of Front Runner - First Steps

The 83-mile FrontRunner connects Ogden to the north with Salt Lake City, and Provo to the south. On a typical weekday, the system carries nearly 20,000 passengers. As the region continues to grow, FrontRunner service expansion is necessary to meet the travel demand on the I-15 corridor. To obtain the long-term goals for this transportation corridor, UTA must make incremental investments in the commuter rail system. This First Steps projects are just that, a first and necessary step in the future of FrontRunner development to continue growing this needed service.

The project that is the subject of this grant application is a second phase of the "First Step" initiatives. As shown in Figure 1, UTA for Phase 1 is also adding a new rail station at Vineyard. This is a fast-growing community located on the southern portion of the FrontRunner system. The new station will include a platform, bus loop, parking and access roads. To build the new station and still maintain operations throughout the rest of the system, UTA will need to add an additional 1.9 miles of double tracking north of the station.

The primary component of this grant application is the double tracking of a 2.5-mile section of track between South Jordan and Draper, which is a critical point of the FrontRunner system. When the FrontRunner entered service in 2008, it was established as a single track service in order to limit the required initial capital investment of the system. In Figure 1, areas of existing double track are in blue, whereas areas of existing single track are in red. Because most of the system is single track, the meets and passes of trains traveling in opposite directions must be carefully coordinated to occur at double track sections. Any delay to the schedule can have cascading impacts, so that if a meet/pass does not occur at the correct time at one location, other trains will be impacted as their scheduled meet/passes are also delayed. The segment between South Jordan and Draper has emerged as a major chokepoint of the system where trains must frequently wait until other trains clear this single line segment before proceeding. By double tracking this segment, these delays and their cascading impacts can be avoided, and the FrontRunner system can operate more reliably. Figure 2 below displays the reliability of FrontRunner service by station and train direction during the second half of 2019. Here, reliability is defined as the percentage of trains that depart the station within five minutes of the scheduled arrival time. The bars in red indicate those stations and directions that would be impacted by the double tracking of the Draper – South Jordan segment. As shown southbound trains at Murray, South Jordan and Draper would be impacted, as well as northbound trains at Murray and Salt Lake. UTA management believes that the project would improve reliability for these trains to over 90 percent. For the purposes of this BCA, reliability is assumed to improve to 92 percent.

Figure 2: Reliability by Station and Direction



A smaller aspect of the project is to improve wayfinding at Vineyard Station, Draper Station, and South Jordan Station. As part of UTA's continued focus on customer experience, new wayfinding guidelines have been identified. The project will involve the first installation of the new signage.

2.2 GENERAL ASSUMPTIONS

UTA typically assigns an estimated useful life of 50 years to track work on tangent (straight) segments of track. The project will take place almost entirely on tangent track, so the estimated useful life of the project is 50 years. Per U.S. DOT guidance, the analysis period has been limited to a shorter duration. In this case, the total analysis period is 30 years, including four years of construction and 26 years after the project enters service.

A discount rate of seven percent has been used, per U.S. DOT Guidance. All costs and benefits have been discounted to 2019. All costs and benefits are stated in constant 2018 real dollars. Any values used in the analysis that were originally obtained in different year base dollar amounts were adjusted to 2018 using the U.S. Gross Domestic Product Implicit Price Deflator (GDP IPD).

2.3 BASE CASE (NO BUILD) AND BUILD CASE

The analysis compares the benefits and costs of two scenarios: a Base Case or No Build Case and a Build Case. For the purposes of this analysis, the No Build case assumes that the segment between Draper and South Jordan stations remains single track. No wayfinding at Vineyard station is provided, and no wayfinding improvements are provided at South Jordan and Draper stations.

In the Build scenario, a second track is added between Draper and South Jordan stations, wayfinding is added at Vineyard station, and improvements are made to wayfinding at South Jordan and Draper stations.

2.4 PROJECT COSTS

2.4.1 *CAPITAL COSTS*

Capital costs represent the environmental, design, and construction of the double tracking, as well as costs associated with wayfinding signage.

Table 1: Project Schedule and Costs, Millions of 2018 Dollars

Variable	Unit	Value
Construction Start	year	2020
Construction End	year	2023
Construction Duration	years	4
Project Opening	year	2024
Capital Cost – Construction	$ M	35.6
Capital Cost – Professional Services	$ M	2.4

Source: UTA

Capital cost estimates for the double tracking originally provided had been escalated by eight percent to 2022 dollars over 2020 estimate dollars. In order to convert to constant $2018 and remove the impacts of nominal inflation between 2018 and 2022, double track capital cost estimates were deescalated using GDP/IPD forecasts from the U.S. Congressional Budget Office (CBO).[3] The CBO forecasts that the GDP/IPD (2012 = 100) will

[3] U.S. Congressional Budget Office, *The Budget and Economic Outlook: 2020 to 2030,* www.cbo.gov/publication/56020.

increase from 110.4 in 2018 to 119.5 in 2022. To deescalate back to $2018, capital costs have been adjusted by about 92 percent (110.5 / 119.5).

Table 2: Double Tracking Costs in $2022 and $2018

Activity	2020	2021	2022	2023
Capital Costs in $2022				
Environmental	$75,000	$40,000		
Design	$205,000	$2,100,000		
Construction			$19,150,000	$19,150,000
Capital Costs in $2018				
Environmental and Design	$258,692	$1,977,146		
Construction			$17,692,685	$17,692,685

The capital costs associated with wayfinding improvements in this project are less. Amounts provided are assumed to be $2018. The capital costs of wayfinding improvements are shown in Table 3 below.

Table 3: Capital Costs of Wayfinding Improvements ($2018)

	Commuter Rail Station ID	Pole Station ID	Rail Platform Sign	Fence Platform Direction Sign	Directional Sign	Fingerpost	Tickets Sign	UTA Beacon (Triangular Prism)	Information Hub Double Sided	On-platform Line Diagram	Total
Units	12	60	6	12	54	12	12	6	6	72	
Unit Cost	$1,144	$806	$1,000	$650	$350	$644	$910	$7,475	$13,140	$1,164	
Subtotal Cost	$13,728	$48,360	$6,000	$7,800	$18,900	$7,722	$10,920	$44,850	$78,842	$83,772	**$320,894**

It is assumed that wayfinding improvements will require five months for design, eight months for procurement, and seven months for construction, starting 1st quarter 2021. Of the $320,894 in costs. $120,894 are assumed to be incurred in 2021 and $200,000 in 2022.

2.4.2 *RESIDUAL VALUE*

Because the benefit analysis period is 26 years but the double tracking's expected useful life is 50 years, the double tracking is expected to retain 48 percent of its useful life at the end of the benefit analysis period, or $18.1 million. When discounted to 2019, the residual value is $2.4 million. Per U.S. DOT guidance, the residual value is treated as a benefit and added to the numerator for the purposes of the benefit/cost ratio.

2.4.3 *OPERATIONS AND MAINTENANCE COSTS, REPAIR AND REHABILITATION COSTS*

Most railroad maintenance of way costs (MOW) including spot and capital maintenance relate to the volume of rail traffic that crosses over a rail line. The more traffic over a rail line, the more it must be maintained. In this BCA analysis, traffic is assumed to be the same in the Build and the No Build scenarios, so the maintenance expenditures should be similar in each scenario. The same number of trains travel over double or single track. Furthermore, the project will be built with concrete ties that have an expected useful life of 55 to 60 years,[4] which is longer than the estimated service life of the project. Because maintenance costs are likely to be similar in the Build and No Build scenarios, no incremental operations and maintenance cost, nor repair and rehabilitation costs have been included.

2.5 PROJECT BENEFITS

Most benefits result from the improved reliability. The project would reduce the frequency of delays on the FrontRunner system, which would benefit passengers through travel time savings.

Although a much smaller source of benefits, the project would also reduce fuel consumption and associated emissions, since locomotives would not need to spend as much time burning fuel while idling.

Another source of benefits is the increased ridership that results from the improved reliability of the FrontRunner service. Research has shown that people tend to remember their experience based on their worst rather than average discomfort.[5] Therefore, an occasional unpleasant experience, such as an unexpected delay can significantly impact travel behaviors. The reduction of delays that will result from the project will reduce the frequency of unpleasant travel experiences and thereby improve rider retention on the system. A significant amount of research has been conducted regarding transit passenger attitudes and the general value that passengers place on service reliability. However, no estimates are available that would, for example, enable an analyst to estimate that an improvement of on-time performance from "x" to "y" percent on-time would result in "z" percent increase in ridership. Instead, the impact of the project on ridership is based on general travel time savings. Research has found that a 10 percent improvement in transit time for rail transit translates to a six percent increase in demand for the service[6]. Therefore, the impacts of the project on average transit times has been estimated to derive a ridership impact.

The benefits associated with the project's impacts on capacity have not been monetized. While double tracking 2.5 miles between Draper and South Jordan will support future expansions of the FrontRunner service, by itself the project does not enable UTA to operate more trains. Rather, this double tracking project will be combined with other future capacity improvements to expand the FrontRunner service. The *Future of FrontRunner* study featured several investment scenarios for the FrontRunner service, ranging from a fully electrified service with double the frequency of trains and a longer corridor, to a more modest investment scenario with a 17-mile extension to the corridor, roughly the same train schedule but longer trains, and 10 miles of additional double track. Resulting growth in ridership ranged from an increase of 11 percent over a base case to 79 percent. In each scenario, double tracking between Draper and South Jordan was considered a necessary improvement. Unfortunately, there is no way to isolate the impact of double tracking between Draper and South Jordan within these scenarios, particularly since each includes a variety of improvements including double tracking, new stations, route extensions, new rolling stock.

The benefits of the wayfinding improvements have also not been quantified. It is likely that the signage will improve passenger experience and save travel time.

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[4] National Precast Concrete Association, "Railroad Ties: Precast Concrete or Wood?", https://precast.org/2010/07/railroadties-precast-concrete-or-wood/.

[5] *The Economist*, "Happiness (And How to Measure It)", December 23, 2006.

[6] Tod Litman, Victoria Transport Policy Institute, *Understanding Transport Demands and Elasticities: How Prices and Other Factors Affect Travel Behavior,* March 18, 2019.

Table 4: Project Benefits by Long-Term Outcome Category

Long-Term Outcome	Benefit (Disbenefit) Category *(These are samples…customize for your project)*	Description	Monetized	Qualitative
Quality of Life / Livability	Better customer experience	Improved wayfinding improves customer experience		√
Economic Competitiveness	Travel Time Savings	Improved reliability provides travel time savings	√	
	Vehicle Operating Costs	Although not quantified, more passengers using FrontRunner incur less vehicle operating costs	√	
	Fuel Savings	Locomotive consume less fuel with fewer delays	√	
Safety	Reduced Incidents	More passengers using FrontRunner pose less highway safety risk	√	
State of Good Repair	Reduced Road Damage	More passengers using FrontRunner cause less road damage	√	
Environmental Sustainability	Reduced Emissions	With fewer delays, locomotives cause fewer emissions. Furthermore, fewer people driving emit lower emissions.	√	

Source: WSP Analysis

3 BENEFIT-COST ANALYSIS DATA AND ASSUMPTIONS

3.1 DEMAND PROJECTIONS

The Base Case of the *Future of FrontRunner* study estimates that even without improvements to the service, the ridership of the FrontRunner service will increase to 35,600 passengers per day in 2050. These forecasts were based on output from a regional travel demand model by the Wasatch Front Regional Council/Mountainland Association of Governments. Data supplied by UTA for a grant application in 2019 indicated that average ridership on a weekday in 2018 was 18,396. Assuming a constant rate of increase, the growth in ridership between 2028 and 2050 would translate to a 2.1 percent increase in ridership per year. This rate of increase has been adopted for this BCA. Although social distancing associated with COVID 19 will dramatically reduce ridership for 2020, it is assumed that long term ridership trends would remain the same.

As discussed previously, the project will likely increase ridership on the FrontRunner due to the improved level of service. Resulting ridership increases have been estimated and will be discussed in more detail in the economic competitiveness section.

3.2 QUALITY OF LIFE / LIVABILITY

This project will create quality of life / livability benefits due to the improved wayfinding at Vineyard, Draper, and South Jordan stations.

3.3 ECONOMIC COMPETITIVENESS

This project would contribute to increasing the economic competitiveness of the Nation through improvements in the mobility of people in the study area. Two types of societal benefits are measured in the assessment of economic competitiveness: travel time savings and vehicle operating savings.

Table 5: Economic Competitiveness Estimation of Benefits, Millions of 2018 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Reduced travel time due to improved reliability	2.3	1.6	77.5	24.9
Reduced fuel consumption due to less locomotive idling	0.01	0.00	0.2	0.1
Less automobile operating and maintenance costs as a result of higher FrontRunner ridership	0.3	0.3	12.5	4.02

Source: WSP Analysis

3.3.1 *TRAVEL TIME SAVINGS*

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities. The project will result in significant travel time savings associated with a more reliable service. According to UTA management, the average train delay is 11.12 minutes or 0.1853 hours. UTA operates 49 end-to-end train trips per weekday and 14 half trips. It is not entirely clear whether reported delays at stations represent discrete delay events or whether delay events impact the on time performance (OTP) statistics at multiple stations. Most likely, the latter occurs, where a delay, for example, on as southbound train at Murray impacts OTP statistics at South Jordan and Draper. To be conservative, it is assumed that total delays can be approximated by the frequency of delays at the station with the lowest on-time performance. Delays reflected at other nearby stations result from the same delay events as the stations with the lowest on-time performance.

UTA management believes that the project will improve OTP at impacted stations above 90 percent with a goal of 95 percent. Given this range, an improvement to 92 percent seems reasonable. Using assumed OTP improvements, the average hours per delay, the number of trains per day as shown in Table 6, the estimated improvement in train delays per day is 1.59 hours.

Table 6: Daily Reduction in Train Delays

Station and Direction	No Build OTP	Build OTP	# Trains/ Day	Hours per Delay Event	Train Delay Hours No Build	Train Delay Hours Build	Reduction in the Delay Hours
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
					(1- a) x c x d	(1-b) x c x d	e - f
Murray SB	**0.789**	**0.92**	**28**	**0.1853**	**1.09**	**0.42**	**0.68**
Murray NB	0.796	0.92	28				
Salt Lake NB	**0.744**	**0.92**	**28**	**0.1853**	**1.33**	**0.42**	**0.91**
South Jordan SB	0.806	0.92	28				
Draper SB	0.827	0.92	28				
Total					**2.61**	**0.89**	**1.59**

According to UTA, the average southbound train carries 158 passengers, while the average northbound train carriers 102 passengers. UTA suggests an annualization factor of 275 to convert from daily to annual statics, so the annual impact on passenger delay hours at 2020 ridership levels (pre COVID 19) is 58,805 as shown in Table 7.

Table 7: Calculation of Annual Reduction in Passenger Delay Hours

Station and Direction	Reduction in Train Delay Hours/Day	Passengers per Train	Reduction Passenger Delay Hrs/Day	Annualization	Reduction Passenger Delay Hrs/Yr
	(a)	(b)	(c)	(d)	(e)
			a x b		c x d
Southbound	0.68	158	107.4	275	29,532
Northbound	0.91	102	93.1	275	25,614
Total	**1.59**		**200.5**		**55,146**

As mentioned previously, an analysis for UTA suggests that ridership will increase at about 2.1 percent per year over the long-term. Applying this growth factor, passenger delays impacted by the project will grow commensurately as shown in Table 8.

Table 8: Forecast Annual Reduction in Passenger Delay Hours

Year	Reduction in Passenger Delay Hours
2024	59,890
2030	67,783
2040	83,314
2049	100,314

As the U.S. DOT Guidance points out, the value of travel time savings for reliability improvements is higher than for scheduled in-vehicle travel. By their nature, unscheduled delays are disruptive and cause transit users more harm than scheduled in-vehicle transit time. As an example, a study in Australia found that unexpected delays impose 3.7 times standard onboard travel time costs. Thus, if 10 percent of trains are ten minutes late, the average lateness of 1 minute would be valued equal to 3.7 minutes onboard time. This unreliability multiplier rises to five in extreme circumstances.[7] The U.S. DOT Guidance recommends valuing waiting time, transfer time, time spent standing in a crowded transit vehicle at twice the value as in-vehicle travel time. However, time spent waiting for an unexpected train delays is more disruptive than time waiting for on-time scheduled service. Given the U.S. DOT multiplier of 2.0 for waiting time and the Australian study's unreliability multiplier of 3.7, an unreliability multiplier of 2.5 was considered reasonable estimate of an unreliability multiplier for this BCA. The multiplier was applied to the personal in-vehicle value of travel time savings of $15.20 to yield $38.00 per hour value of avoided delays.

3.3.2 *OPERATING COST SAVINGS – AVOIDED VEHICLE MILES TRAVELED*

Vehicle operating cost savings includes the cost of fuel, as well as maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. Consumption rates per vehicle mile travelled (VMT) are used to

[7] Douglas Economics for RailCorp, *Value and Demand Effect of Rail Service Reliability,* 2006, cited in Victoria Transport Policy Institute, *Valuing Transit Service Quality Improvements, Considering Comfort and Convenience in Transport Project Evaluation.* November 2011, pp. 11 – 12, http://www.trpa.org/documents/rseis/New%20References%20for%20Final%20EIS/Victoria%20Transport%20Policy%20Institute%202011.pdf.

calculate the vehicle operating cost savings. Estimates of VMT and unit costs for each component of vehicle operating cost are applied to the consumption rates to calculate the total vehicle operating cost.

The project's impact on ridership and vehicle miles traveled has been estimated using an elasticity factor of -0.60. Research has found that a percentage decrease in trip time translates to a 0.6 percent increase in demand for the transit service.[8]

According to the Federal Transit Administration's National Transit Database, FrontRunner handled 129.7 million passenger miles and 5.082 million unlinked trips in 2018, so the average mileage per trip was 25.52. The same year the number of transit vehicle miles was 5.429 million, and the number of transit vehicle hours was 164,930, so the average speed per vehicle was 32.92 miles per hour. Dividing the average distance by the average speed, the typical trip duration was 25.52 miles ÷ 32.92 miles per hour = 0.775 hours. For those trains that are delayed, the delay adds about 0.1853 hours ÷ 0.775 = 24 percent to the trip time. However, only minority of trips are delayed and impacted by the project. Table 9 shows many of the same statistics as Table 6, but the change in Build/No Build OTP is multiplied by the average delay to estimate an average reduction delay per passenger. This, multiplied by the average trip time, is used to estimate the average percent reduction in trip time resulting from the project. The decrease in trip time is then multiplied by the elasticity factor to estimate the change in demand (ridership) that results from the project.

Table 9: Calculation of Percent Change in Ridership as a Result of Project

Direction	No Build OTP	Build OTP	Change Build/ No Build OTP	Hours/ Delay	Average Chg Delay/ Passenger	Avg Trip Time	% Decrease Trip Time	Elasticity of Demand	% Change Demand
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
			b - a		c x d		e ÷ f		g x h
Southbound	0.789	0.92	0.131	0.1853	0.024	0.775	0.031	0.6	0.019
Northbound	0.744	0.92	0.176	0.1853	0.033	0.775	0.042	0.6	0.025

It is necessary to then convert the percent change in ridership to an annual ridership impact as shown in Table 10. In this case, the percent change in demand is multiplied by the number of trains per day and passengers per train to derive the change in daily ridership. This is then multiplied by an annualization factor to estimate the project's annual impact on ridership.

[8] Kenneth Small and Clifford Winston, "The Demand for Transportation: Models and Applications," in *Essays in Transportation Economics and Policy,* Brookings Institute, 1999, cited in Victoria Transportation Policy Institute, *Understanding Transport Demands and Elasticities, How Prices and Other Factors Affect Travel Behavior*, March 2019, Table 10, https://www.vtpi.org/elasticities.pdf.

Table 10: Calculation of Project Impacts on Daily and Annual Ridership

Direction	% Change Demand	# Trains/Day	Passengers/Train	Change in Daily Ridership	Annualization	Change in Annual Ridership
	(a)	(b)	(c)	(d)	(e)	(f)
				a x b x c		d x e
Southbound	0.019	28	158	83.1	275	22,860
Northbound	0.025	28	102	72.1	275	19,827
Total				155.2	275	42,688

The ridership impacts shown in Table 10 are based on 2020 ridership levels. These are increased by 2.1 percent per year to account for ridership growth over the project period per Table 11.

Table 11: Forecast Annual Increase in Ridership as a Result of the Project

Year	Ridership Increase
2024	46,360
2030	52,469
2040	64,492
2049	77,651

The next step is to convert increases in ridership as a result of the project to impacts on vehicle miles traveled. As mentioned above, the average distance per trip is 25.52 miles. However, passenger miles added onto the FrontRunner do not equal savings in vehicle miles traveled (VMT) because not all of the FrontRunner passengers would have otherwise driven alone. According to *Moving Toward 2020: Utah Commuting Patterns 2000 to 2010*,[9] 75.7 percent of commuters in Utah drive alone. Therefore, it is assumed that 75.7 percent of additional passengers would have otherwise driven alone. The resulting adjustments are shown in Table 12.

Table 12: Forecast Annual Decrease in VMT as a Result of the Project

Year	Ridership Increase	Average Distance per Trip	Percent Passengers who Would Have Driven Alone	Avoided Vehicle Miles Traveled
	(a)	(b)	(c)	(d)
				a x b x c
2024	46,360	25.52	0.757	895,452
2030	52,469	25.52	0.757	1,034,579
2040	64,492	25.52	0.757	1,245,678
2049	77,651	25.52	0.757	1,499,849

The project would enable passengers to avoid using their automobiles and thereby paying for vehicle operating costs. Per U.S. DOT Guidance, avoided light duty vehicle operating cost is assumed to be $0.41 per VMT.

[9] Kern C. Gardner Policy Institute, University of Utah, *Moving Toward 2020: Utah Commuting Patterns, 2000 to 2010,* Table 1, https://gardner.utah.edu/wp-content/uploads/CommutingReport-Jan2020.pdf.

Because trains would be delayed less often, locomotives would burn less fuel idling. Per calculations shown in Table 6, avoided hours of train delay per day would be 1.59. The U.S. EPA estimates that switch locomotives consume between three and 11 gallons per hour depending on the temperature.[10] The fuel consumption rate at idle of FrontRunner locomotives is assumed to be similar to that of switcher locomotives, and five gallons per hour is used as an estimated fuel consumption rate of idling locomotives. Assuming one diesel locomotive per train and multiplying by an annualization factor of 275 and five gallons per hour, the total avoided gallons of fuel per year is estimated to be 2,190. Fuel savings are multiplied by the retail cost of diesel fuel net of federal and state taxes. The retail cost of diesel is based on forecasts by the U.S. Energy Information Administration Annual Energy Outlook 2019. Total discounted benefits during the project period of rail fuel savings is $53,244 in $2018.

3.4 SAFETY

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from the project. Because the project will enable FrontRunner to retain/attract passengers that otherwise would have driven automobiles, it will improve safety of the roadway system. Rail is a relatively safe mode of transportation compared to highway travel, and moving passengers from roadway to rail transportation provides safety benefits. Benefits are summarized in Table 13.

Table 13: Safety Estimation of Benefits, Millions of 2018 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Fatality Reduction	$0.08	$0.05	$2.59	$0.83
Injury Reduction	$0.12	$0.09	$4.41	$1.42
Property Damage Reduction	$0.01	$0.00	$0.00	$0.00
Total Safety Benefits	$0.21	$0.15	$7.00	$2.25

Source: WSP Analysis

The analysis assumes constant accident rates for the “Build” and “No Build” scenarios. As a result, any changes in the number of accidents will be a result of changes in VMT, not of structural changes to the safety conditions on the roadway network. The assumptions used in the estimation of safety benefits are presented in Table 14. Accident rates were derived from the State of Utah Department of Public Safety Highway Safety Office *Utah Crash Facts 2018* publication.[11] This publication estimated the number of fatalities per 100 million VMT to be approximately 0.8. Injury and property damage only (PDO) crash statistics were derived based on the relative frequency when compared to fatalities.

[10] U.S. EPA, “Locomotive Switcher Idling and Idle Control Technology,” June 2005.
[11] https://highwaysafety.utah.gov/wp-content/uploads/sites/22/2020/02/2018-Crash-Facts-Summary.pdf

Table 14: Safety Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost per Fatality	2018$	$9,600,000	US DOT Guidance, January 2020
Cost per Injury Crash	$2018	$250,600	US DOT Guidance, January 2020
Cost per Property Damage Only Crash	$2018	$4,400	US DOT Guidance, January 2020
Rate of Fatalities per 100 Million VMT	#/per 100M VMT	0.8	Utah Department of Public Safety, *Utah Cash Facts*
Rate of Injury Crashes per 100 Million VMT	#/per 100M VMT	55.3	Utah Department of Public Safety, *Utah Cash Facts*
Rate of Property Damage only Crashes per 100 Million VMT	#/per 100M VMT	135.0	Utah Department of Public Safety, *Utah Cash Facts*

Source: U.S. DOT Guidance and Utah Crash Facts

3.5 STATE OF GOOD REPAIR

The state of good repair benefits assessed in this analysis includes reduced VMT which leads to less road and pavement damage. The rate of pavement damage per VMT is based on the 2000 U.S. Federal Highway Administration (FHWA) *Cost Allocation Study*, indexed to $2018 and assuming 100 percent urban roadway travel. The amount per VMT is $0.0017. Total benefits over the study period discounted at seven percent are $17,096.

3.6 ENVIRONMENTAL SUSTAINABILITY

This project will create environmental and sustainability benefits relating to reduction in air pollution associated with decreased automobile and reduced train idling. Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. Benefits are summarized in Table 15.

Table 15: Environmental Sustainability Estimation of Benefits, Millions of 2018 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
CO2 Emissions Reduction	$0.00	$0.00	$0.01	$0.00
NOx Emissions Reduction	$0.00	$0.00	$0.02	$0.01
SOx Emissions Reduction	$0.00	$0.00	$0.03	$0.01
PM Emissions Reduction	$0.00	$0.00	$0.00	$0.00
VOC Emissions Reduction	$0.00	$0.00	$0.01	$0.00
Total Emissions Reduction	$0.00	$0.00	$0.06	$0.02

Source: WSP Analysis

The assumptions used in the estimation of environmental sustainability benefits are presented in Table 16. Emissions factors of automobiles assumed an average speed of 45 miles per hour.

Table 16: Environmental Sustainability Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO_2 emissions	2018$ per short ton	$1 through 2035, $2 thereafter	US DOT Guidance, January 2020
Cost of NOx emissions	2018$ per short ton	$8,600.00	US DOT Guidance, January 2020
Cost of PM10 emissions	2018$ per short ton	$387,300.00	US DOT Guidance, January 2020
Cost of SOx emissions	2018$ per short ton	$50,100.00	US DOT Guidance, January 2020
Cost of VOC emissions	2018$ per short ton	$2,100.00	US DOT Guidance, January 2020
Emissions per VMT	Grams of emissions per VMT	Varies by year, fuel type, and emission type	California Air Resources Board EMFAC Database, 2017; Cal B/C, 2010; EPA MOVES, 2014
Emissions Speed Adjustment Factors	Factor	Varies by year, fuel type, emission type, and speed	California Air Resources Board EMFAC Database, 2014

4 SUMMARY OF RESULTS

4.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a Project. When calculating the payback period, the time value of money (discounting) is not taken into account.

4.2 BCA RESULTS

The table below presents the evaluation results for the project. Results are presented in undiscounted, discounted at 7 percent and discounted as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2018 dollars over an evaluation period extending 26 years beyond project completion in 2023. The benefits of the project exceed the costs at a seven percent discount rate, resulting in a benefit/cost ratio of 1.12 and a net present value of $3.5 million. The internal rate of return of the project is eight percent with a payback period of 12 years.

Table 17: Benefit Cost Analysis Results, Millions of 2018 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (7%)
Total Benefits	$115.3	$33.7
Total Costs	($37.9)	($30.2)
Net Present Value (NPV)	$77.4	$3.5
Benefit Cost Ratio (BCR)	3.04	1.12
Internal Rate of Return (IRR)	8.0%	N/A
Payback Period (Years)	12	25

Source: WSP Analysis

The benefits over the project lifecycle are presented in the table below by U.S. DOT long-term outcome category. Most of the benefits (74 percent) result from travel time savings due to passengers no longer being delayed because of the single track segment between Draper and South Jordan. Other benefits relate to the project increasing ridership on the FrontRunner and thereby reducing VMT. These primarily consist of safety benefits (seven percent of benefits) and reduction in vehicle operating costs (12 percent of benefits).

Table 18: Benefits by Long-Term Outcome, Millions of 2018 Dollars

Type of Benefit	Undiscounted	Discounted
Travel Time Savings	$77.5	$24.9
Safety	$7.0	$2.3
Vehicle Operating Cost Savings (including Fuel)	$12.7	$4.1
Reduced Pavement Damage	$0.1	$0.0
Reduced Emissions	$0.1	$0.0
Residual Value	$18.1	$2.4

Source: WSP Analysis

4.3 SENSITIVITY TESTING

A sensitivity analysis is used to help identify which variables have the greatest impact on the BCA results. Because most of the impacts of the project relate to the value of travel time savings, the results are sensitive to assumptions regarding the value of travel time savings. As mentioned previously, an estimated reliability multiplier of 2.5 was applied to in-vehicle travel time. If instead, a multiplier equivalent to the U.S. DOT prescribed wait time of 2.0 was used, the BCR would have declined to 0.95 with an NPV of negative $1.5 million. On the other hand, the in-vehicle value of travel time savings to which the reliability multiplier was applied was $15.20 per hour, which assumes FrontRunner is only used for personal trips. If the 2.0 multiplier had been used and this multiplier were applied to an all purpose value of $16.60 per hour, the resulting BCR would have been 1.01 with a NPV of $0.3 million. Had the unreliability multiplier of 3.7 from the Australian study cited earlier been applied, the BCR would have been 1.51 with an NPV of $15.4 million.

The analysis is also sensitive to assumptions regarding the ridership impacts. Ridership impacts were derived by estimating the total percentage impact of the project on average trip times and then applying an elasticity factor to that percentage trip time change. However, unexpected delays that the project aims to alleviate likely have a higher impact on ridership than changes in trip time alone. Had delay hours been multiplied by 2.5 in the ridership estimation to account for the relatively higher impact of delays on ridership, the BCR would have increased to 1.43 with an NPV of $12.9 million.

Table 19: Benefit Cost Analysis Sensitivity Analysis, Millions of 2018 Dollars

Sensitivity Analysis	New BCR	New NPV
Reduce unreliability VTTS multiplier from 2.5 to 2.0	0.95	($1.5)
Reduce unreliability VTTS multiplier from 2.5 to 2.0 but then multiply by all purpose in vehicle VTTS of $16.60 instead of $15.20	1.01	$0.3
Increase unreliability VTTS multiplier from 2.5 to 3.7	1.51	$15.4
Increase average delay per passenger by 2.5 when estimating project ridership impacts to account for higher impact of unreliability on ridership	1.43	$12.9

Source: WSP Analysis